American Journal of Medical Genetics 73:170–175 (1997)

Clinical and Epidemiological Characteristics of Infants With Body Wall Complex With and Without Limb Deficiency

M.L. Martínez-Frías*
ECEMC and Departamento de Farmacología, Facultad de Medicina, Universidad Complutense, Madrid, Spain

The spectrum of defects in cases with limb body wall complex (LBWC) is quite variable since other anomalies are also observed in infants with LBWC, and some cases do not have limb deficiencies. Van Allen et al. [Am J Med Genet 1987;28:529–548] proposed that the diagnosis of LBWC (presence of body wall defects with evisceration of thoracic and/or abdominal organs, limb deficiency, and myelocystocele) should be based on the presence of two of three of the following anomalies: exencephaly or encephalocele with facial clefts, thoraco and/or abdominoschisis, and limb defects. This approach implies that an infant with encephalocele with facial clefts and limb defects may be considered as having LBWC, which I do not think is correct.

I present the results of a clinical and epidemiological analysis aimed at identifying if, from an epidemiological perspective, it is possible to identify an entity which is characterized by the presence of abdominal wall defects along with other malformations including or not limb deficiencies. The result of this analysis allows us to consider that this entity should be characterized by the presence of abdominal wall defects with a variable spectrum of anomalies (with or without limb deficiencies) and, consequently, be called body wall complex (BWC). BWC includes cases regardless of their clinical pattern and the possible etiology or pathogenetic mechanism. Thus, the BWC entity does not include amniotic band sequence *without* body wall defects, but does include amniotic band sequence *with* body wall defects. Am. J. Med. Genet. 73:170–175, 1997. © 1997 Wiley-Liss, Inc.

KEY WORDS: body wall complex; anomalies; abdominal wall defects

INTRODUCTION

The presence of body wall defects (usually lateral) with evisceration of thoracic and/or abdominal organs (thoraco- and/or abdominoschisis), limb deficiency, and myelocystocele, is considered a limb body wall complex (LBWC) [Miller, 1983; Pagon et al., 1979]. However, the spectrum of defects is quite variable since other anomalies are also observed in infants with LBWC, and some cases do not have limb defects. Van Allen et al. [1987a,b] proposed that the diagnosis of LBWC should be based on the presence of two of three of the following anomalies: exencephaly or encephalocele with facial clefts, thoraco and/or abdominoschisis, and limb defects. This approach implies that an infant with encephalocele with facial clefts and limb defects may be considered as having LBWC, which I do not think is correct. Thus, I consider that this entity should be characterized by the presence of abdominal wall defects with a variable spectrum of other anomalies and, consequently, be called body wall complex (BWC).

There are, at least, four theories on the pathogenesis of the BWC. (1) It has been proposed that this entity could be the results of a defect in the germ disc with an early embryonic maldevelopment [Streeter, 1930; Herva et al., 1984; Bamforth, 1992]. (2) Torpin [1965] considered that a primary rupture of the amnion causes direct mechanical pressure leading to the formation of amniotic bands. This theory was accepted widely [Miller et al., 1981; Seeds et al., 1982; Kalousek and Bamforth, 1988; Luebke et al., 1990]. (3) Van Allen et al. [1987a] suggested that BWC results from a vascular disruption and stated that this could be due to "altered vascular blood flow, leading to disruption and incomplete development of embryonic tissue due to hemorrhagic necrosis and anoxia." These authors think

Contract grant sponsor: Dirección General de Salud Pública del Ministero de Sanidad y Consumo of Spain; Contract grant sponsor: Fundación ONCE of Spain.

*Correspondence to: Dr. M.L. Martínez-Frías, ECEMC, Facultad de Medicina, Universidad Complutense, 28040, Madrid, Spain.

Received 17 February 1997; Accepted 9 May 1997

that the disruption of the developing embryo most likely occurs in the 4th through 6th weeks of gestation. (4) Hartwig et al. [1989, 1991] proposed a disturbance of the embryonic folding process related to a malfunction of the body wall ectodermal placode. Russo et al. [1993] concluded that this may be the mechanism for those BWC phenotypes without craniofacial defects, but with abdominal placenta attachment, short attached umbilical cord, persistence of the extraembryonic coelom, urogenital anomalies, and anal atresia related to the persistence of the primitive cloaca.

Here I present a clinical and epidemiological analysis of a series of consecutive infants with BWC separating those with and without limb reduction defects. The aim of this analysis was to identify if, from an epidemiological perspective, it is possible to recognize an entity comprising abdominal wall defects with a variable spectrum of other anomalies, with or without limb deficiencies.

MATERIALS AND METHODS

The data are derived from the Spanish Collaborative Study of Congenital Malformations (ECEMC). This is a hospital-based case-control study and surveillance system with a methodology aimed not only at the surveillance of congenital anomalies, but also at the investigation of their characteristics, clusters of congenital malformations, and the causes of congenital defects. Each child born in any of the participant hospitals is examined by pediatricians who, being interested in the problem of congenital anomalies, collaborate with the ECEMC program and follow its strict methodology. They examine the newborn infants within the first three days of life to identify major and/or minor defects. In each case, the next nonmalformed infant of the same sex born in the same hospital is selected as a control subject. Once the case and control infants have been identified, the same physicians interview the mothers of case and control infants, using defined protocols, to gather information on family history, obstetrical data, prenatal exposures, etc. In many instances, photographs, imaging studies, karyotypes, pathology reports, and other complementary studies are also available for review. The ECEMC methods have been published previously [Martínez-Frías, 1994, 1995; Martínez-Frías and Urioste, 1994].

We have considered the BWC in those infants with evisceration of the thoracic and/or abdominal organs (not omphalocele). The difference between BWC and gastroschisis was established on the basis of other malformations. Thus, those infants with "gastroschisis" associated with other major malformations are included as cases with BWC. We excluded one twin described as acardio-anencephalus with gastroschisis, without any other information.

Between April 1976 and March 1996, the ECEMC has surveilled a total population of 1,309,850 liveborn infants. Among them, 24,366 had major and/or minor anomalies detected at birth and 15 had BWC. Between January 1980 and March 1996, a total of 8,572 stillborn infants were analyzed and 492 of them had congenital anomalies. Among these, 16 had BWC.

RESULTS

Table I shows the global and annual prevalences of live and stillborn infants with BWC as well as total

TABLE I. Study Population: Prevalences by Years

	Livebirths			Stillbirths			Total		
Year	N	Births	Prevalence[a]	N	Births	Prevalence[a]	N	Births	Prevalence[a]
1976	0	12,234	—	—	—	—	—	—	—
1977	0	27,426	—	—	—	—	—	—	—
1978	0	35,533	—	—	—	—	—	—	—
1979	1	68,786	0.15	—	—	—	—	—	—
1980	1	60,289	0.17	0	562	—	1	60,851	0.16
1981	2	58,684	0.34	0	495	—	2	59,179	0.33
1982	2	69,080	0.29	1	539	18.55	3	69,619	0.43
1983	1	77,939	0.13	1	587	17.04	2	78,526	0.25
1984	1	72,642	0.14	1	542	18.45	2	73,184	0.27
1985	1	67,643	0.15	2	557	35.91	3	68,200	0.44
1986	2	57,769	0.35	0	476	—	2	58,245	0.34
1987	1	50,664	0.20	3	387	77.52	4	51,051	0.78
1988	0	52,278	—	1	408	24.51	1	52,686	0.19
1989	0	58,635	—	1	411	24.33	1	59,046	0.16
1990	1	83,759	0.12	2	620	32.26	3	84,379	0.36
1991	1	87,045	0.11	1	663	15.08	2	87,708	0.23
1992	1	91,032	0.11	0	575	—	1	91,607	0.11
1993	0	82,358	—	0	567	—	0	82,925	—
1994	0	86,705	—	3	534	56.18	3	87,239	0.34
1995	0	86,842	—	0	530	—	0	87,372	—
1996	0	22,507	—	0	119	—	0	22,626	—
Total	15	1,309,850	0.11	16	8,572	19.83	31	1,174,443	0.26
	$\chi^2_{20} = 13.11$ Not significant			$\chi^2_{16} = 19.15$ Not significant			$\chi^2_{16} = 14.44$ Not significant		

[a]Prevalence per 10,000.

TABLE II. Sex Ratio by Study Group

	Males	Females	M/F	Absence	Total
BWC with limb defects	8	5	1.6	3	16
BWC without limb defects	6	5	1.2	4	15
Total BWC	14	10	1.4	7	31
Total livebirths	674,043	635,672	1.06	0	1,309,850

TABLE IV. Gestational Age (in Weeks) by Study Group

	Number	Mean	SD	*P*
BWC with limb defects	15	35.43	3.75	Not significant
BWC without limb defects	14	35.30	3.39	
Total BWC	29	35.36	3.52	(*)

(*) Vs. the control group (Table IX), $P \ll 0.001$.

births. The differences between the years are not statistically significant. The prevalence among stillborn infants is 180 times higher than among livebirths.

Table II analyzes the sex ratio of infants with BWC with and without limb deficiencies. The differences are not significant, nor with the sex ratio of the general population.

Tables III and IV analyze the birth weight and gestational age, respectively. Both measures are similar in cases with and without limb deficiencies. The comparison between the means of birth weight and gestational age of the total cases with BWC with those of the control group shows that they are significantly lower in infants with BWC. The mean birth weight is under the 3rd centile for a mean gestational age of 35 weeks. It is also clear that the low birth weight is not due to the absence of limbs, because the same low birth weight is observed in infants with BWC without limb deficiencies.

Tables V and VI show that the means of maternal (Table V) and paternal (Table VI) age are not different in cases with and without limb reduction defects. The global means of cases with BWC are significantly lower than those observed in the control population. Table VII analyzes the mean differences between paternal and maternal ages. Both study groups as well as the control group (Table IX) have similar means.

Table VIII depicts the mean of the number of previous pregnancies in each study group. The differences between cases with and without limb deficiencies are also statistically not significant, but the mean among total cases with BWC is significantly smaller than in the control group. This is concordant with the lower mean maternal age of cases with BWC.

Table IX shows the data of the control group. Table X analyzes the frequency of different malformations in both study groups. Table X also indicates the relative frequency (RF), i.e., the times in which each congenital defect is more frequent among children with limb deficiencies than in those without limb defects. This RF is obtained by dividing the percentages from the group of BWC infants with limb deficiencies by the corresponding percentages observed in the group without limb deficiencies. Hydrocephaly and anal atresia are three times more frequent among BWC infants without limb defects. Neural tube defects and anomalies of female internal genitalia are also two times more frequent among this group without limb deficiencies. On the other hand, agenesis of the diaphragm is nearly three times more frequent among the group with limb deficiencies, and renal anomalies and bladder agenesis are about two times more frequent also in the group with limb reduction defects. Nevertheless, the differences between the frequencies observed in each study group are not statistically significant.

In 11 cases, the number of vessels in the umbilical cord was specified, and in 7 of them there were only two vessels. Even assuming that the rest of the 20 cases with the data unspecified had three vessels, the percentage of cases with only two vessels (22.6%) is very high, considering that in our data only 2.10% of the malformed infants without BWC has two vessels.

Among the cases with limb deficiencies and specified data, the lower limbs were affected in 60% of the cases, in 26.67% the upper limbs, and in 13.33% upper and lower limbs. On the other hand, the left side was affected in 40% of the cases, the right side in 20%, and both sides in 40% of the cases.

DISCUSSION

The results of this analysis indicate that those infants with BWC and limb defects have similar epidemiological characteristics to those with BWC without limb defects. This indicates that we cannot consider the presence of limb deficiencies as one of the malformations that defines this entity. The hallmark anomaly for this complex should be the body wall defect that may be associated with a large spectrum of anomalies including limb deficiencies, as I have shown in Table X.

From the present epidemiological analysis, I conclude that infants with BWC (with or without limb deficiencies) present very low birth weight and short gestational age. This is also observed in the series published by Moerman et al. [1992]. The present cases

TABLE III. Birth Weight by Study Group

	Number	Mean	SD	*P*
BWC with limb defects	14	1,471.07	613.82	Not significant
BWC without limb defects	11	1,768.64	965.52	
Total BWC	25	1,602	784.37	(*)

(*) Vs. the control group (Table IX), $P \ll 0.001$.

TABLE V. Mean Maternal Age in Each Study Group

	Number	Mean	SD	*P*
BWC with limb defects	16	24.38	5.58	Not significant
BWC without limb defects	15	25.13	4.78	
Total BWC	31	24.74	5.14	(*)

(*) Vs. the control group (Table IX), $P < 0.01$.

TABLE VI. Mean Paternal Age in Each Study Group

	Number	Mean	SD	*P*
BWC with limb defects	16	27.06	8.46	Not significant
BWC without limb defects	14	28.14	4.45	
Total BWC	30	27.57	6.80	(*)

(*) Vs. the control group (Table IX), $P < 0.01$.

TABLE VIII. Mean Number of Pregnancies by Mothers in Each Study Group

	Number	Mean	SD	*P*
BWC with limb defects	15	1.93	1.75	Not significant
BWC without limb defects	15	1.2	0.41	
Total BWC	30	1.57	1.30	(*)

(*) Vs. control group (Table IX), $P = 0.05$.

have a small preponderance of males (sex ratio 1.4). The means of maternal and paternal ages are younger than those of the control group. Consequently, most cases (70.97%) are the result of the first pregnancy. These results are similar to those observed in cases with gastroschisis, another abdominal wall defect. However, the birth weight of cases with gastroschisis [Martínez-Frías et al., 1984] is higher than in cases with BWC for a similar mean of gestational age. As was observed previously, a high proportion of cases with BWC have only two vessels in the umbilical cord. Apart from the prevalence figures, the rest of the epidemiological characteristics observed in the present study are different from those observed by Kurosawa et al. [1994] in Japan. This could be due to differences in the definition of cases, since those authors based the diagnosis of LBWC on the criteria proposed by Van Allen et al. [1987a,b]. As I have already stated in the introduction, I consider these criteria rather inappropriate since cases without body wall defects but with other malformations such as encephalocele, oral cleft, and limb deficiencies, may be included as LBWC. Similarly, the epidemiological characteristics given by Luebke et al. [1990] are also different from the present ones. This may also be due to differences in the definition of cases. The differences with the results given by Mastroiacovo et al. [1992] could also be due to the classification of cases with body wall defects, since these authors included those cases with low limb amelia. Although no gross abdominal defects were described, in many cases exomphalos, omphalocele, or gastroschisis were described. However, Mastroiacovo et al. [1992] also observed a low mean maternal age.

I have tried to classify the present cases according to the four pathogenetic theories. Sixteen cases had blastogenetic anomalies; thus, Streeter's [1930] theory of a defect in the germ disc with early embryonic maldevelopment explains the multiple congenital anomaly (MCA) pattern of these infants. In one case, we may assume a vascular process without amniotic bands [Van Allen et al., 1987a,b; Moerman et al., 1992]. In three cases, the infants presented amniotic bands together with body wall defects, limb deficiencies, and craniofacial anoamlies. These cases could be classified, following Torpin's [1965] theory, as a result of the primary rupture of the amnion. However, in two other cases, there were amniotic bands with a MCA pattern including blastogenetic malformations. These are similar to those observed previously by many other authors [Higginbottom et al., 1979; Pagon et al., 1979; Herva and Karkinen-Jääskeläinen, 1984; Hunter and Carpenter, 1986; Donnai and Winter, 1989]. These cases may be examples of the mechanism proposed by Van Allen et al. [1987a,b] of altered vascular blood flow leading to disruption and incomplete development of the embryonic tissue, but this disruption must occur before the 4th week as proposed by those authors. However, Hartwig et al. [1989] proposed a malfunctioning of the ectodermal placodes suggesting a primary malformation process. Donnai and Winter [1989] viewed these cases as the result of the effect of a mutation in the human equivalent to the mouse disorganization gene. Eight of our cases could be considered as due to a disturbance of the embryonic folding process as proposed by Hartwig et al. [1989, 1991] and Russo et al. [1993], because they do not have craniofacial defects [Russo and Vecchione, 1996] but presented with urogenital anomalies and anal atresia. Finally, I could not classify the last case, who only had a body wall defect and limb deficiencies without any evidence of amniotic bands. These results allow us to conclude that the entity of BWC is pathogenetically heterogeneous, and that all the proposed pathogenetic mechanisms of the so-called LBWC may be possible, leading to different subgroups of BWC.

The clinical analysis of the present cases (Table X) suggests that BWC is also a clinically heterogeneous entity, as has been widely documented [Pagon et al., 1979; Van Allen et al., 1987a,b; Litwin et al., 1988; Tang et al., 1991; Martínez-Frías et al., 1992; Moerman et al., 1992; Kurosawa et al., 1994]. Over one half of the cases (55% in this study) present blastogenetic anomalies. Although the differences are not statistically sig-

TABLE VII. Mean Differences Between Paternal and Maternal Ages in Each Study Group

	Number	Mean	SD	*P*
BWC with limb defects	16	2.69	4.30	Not significant
BWC without limb defects	14	2.43	3.39	
Total BWC	30	2.57	3.84	(*)

(*) Vs. the control group (Table IX), not significant ($P > 0.05$).

TABLE IX. Data of the Control Group

	Number	Mean	SD
Birth weight	23,747	3,312.4	477.02
Gestational age (weeks)	22,448	39.44	1.78
Number of pregnancies	23,724	2.05	1.29
Maternal age	23,776	27.48	5.34
Paternal age	23,282	30.36	5.74
Mean parental age differences	23,279	2.84	3.45

TABLE X. Number of Cases by Pattern of Defects in Each Study Group

Defects	BWC with limb defects N (%)	BWC without limb defects N (%)	RF
Hydrocephaly	1 (6.25)	3 (20)	0.31
Cranial disruption by bands	2 (12.5)	2 (13.33)	0.94
Neural tube defects	3 (18.75)	6 (40)	0.47
Anophthalmia/microphthalmia	1 (6.25)	1 (6.67)	0.94
Cleft lip +/− palate	0	4 (26.67)	—
Congenital heart defects	0	3 (20)	—
Ectopia cordis	2 (12.5)	0	—
Agenesis of diaphragm	3 (18.75)	1 (6.67)	2.81
Polydactyly	0	1 (6.67)	—
Renal anomalies	6 (37.5)	3 (20)	1.89
Absence of external genitalia	3 (18.75)	5 (33.33)	0.56
Anal atresia	1 (6.25)	3 (20)	0.31
Other intestinal defects	5 (31.25)	5 (33.33)	0.94
Anomalies of female internal genitalia	1 (6.25)	2 (13.33)	0.47
Ureteral agenesis	2 (12.5)	0	—
Bladder agenesis	2 (12.5)	1 (6.67)	1.87
Total cases	16 (100)	15 (100)	

nificant, it is noteworthy that renal anomalies are more frequent in those infants with BWC and limb deficiencies (Table X). This is probably related to the alteration of the acro-renal primary polytopic developmental field. The same occurs with agenesis of the diaphragm which is more frequent in the group with limb defects. As was previously observed [Martínez-Frías, 1996], the association of limb deficiencies and diaphragmatic anomalies also constitutes a primary polytopic developmental field defect.

Donnai and Winter [1989] proposed that a disruption of genetic origin could be the reason for some of the LBWC cases. Viscarello et al. [1992] presented a case of LBWC prenatally exposed to high doses of cocaine. More recently, Bach et al. [1993] described two unrelated cases who presented with body stalk anomaly complex who were exposed during the blastogenetic period to quinolones. These cases support the assumption of causal heterogeneity, which also supports the hypothesis of a blastogenetic origin for some cases of BWC which will represent the dysmorphogenetic response of the primary developmental field. Thus, it is not surprising to observe blastogenetic and developmental field defects among the patterns of some cases of BWC, as documented in Table X.

In conclusion, I propose that those cases with body wall defect be classified in two main groups: gastroschisis, for cases with an isolated (and usually small) body wall defect; and BWC, for those cases with the body wall defect associated with other malformations, deformations, or disruptions, regardless of their clinical pattern and the possible etiology or pathogenetic mechanism. These two groups should be separated from the amniotic band sequence (ABS) without body wall defects. By doing so, with the increasing number of cases with BWC, we will be able to separate them by the four pathogenetic groups, epidemiologically analyze if they are different, and increase our knowledge on their characteristics and possible causes.

ACKNOWLEDGMENTS

I thank all the physicians who collaborated with the ECEMC in collecting the data.

REFERENCES

Bach C, López E, Sabriá J (1993): Defectos congénitos de la pared abdominal poco frecuentes. A propósito de dos casos en los que se constata la exposición embrionaria precoz a las quinolonas. Prog Diagn Prenat 5:13–17.

Bamforth JS (1992): Amniotic band sequence: Streeter's hypothesis reexamined. Am J Med Genet 44:280–287.

Donnai D, Winter RM (1989): Disorganisation: A model for "early amnion rupture." J Med Genet 26:421–425.

Hartwig NG, Steffelaar JW, Van De Kaa C, Schueler JA, Vermeij-Keers C (1991): Abdominal wall defect associated with persistent cloaca. Am J Clin Pathol 96:640–647.

Hartwig NG, Vermeij-Keers CHR, De Vries HE, Kagie M, Kragt H (1989): Limb body wall malformation complex. Hum Pathol 20:1071–1077.

Herva R, Karkinen-Jääskeläinen M (1984): Amniotic adhesion malformation syndrome: Fetal and placental pathology. Teratology 29:11–19.

Higginbottom MC, Jones KL, Hall BD, Smith DW (1979): The amniotic band disruption complex: Timing of amniotic rupture and variable spectra of consequent defects. J Pediatr 95:544–549.

Hunter AGW, Carpenter BF (1986): Implications of malformations not due to amniotic bands in the amniotic band sequence. Am J Med Genet 24:691–700.

Kalousek DK, Bamforth S (1988): Amnion rupture sequence in previable fetuses. Am J Med Genet 31:63–73.

Kurosawa K, Imaizumi K, Masuno M, Kuroki Y (1994): Epidemiology of limb-body wall complex in Japan. Am J Med Genet 51:143–146.

Litwin A, Merlob P, Grunebaum M (1988): Complete absence of external genitalia in limb-body wall complex: Two cases. J Med Genet 25:340–343.

Luebke HJ, Reiser CA, Pauli RM (1990): Fetal disruptions: Assessment of frequency, heterogeneity, and embryologic mechanisms in a population referred to a community-based stillbirth assessment program. Am J Med Genet 36:56–72.

Martínez-Frías ML (1994): Epidemiological analysis of outcomes of pregnancy in diabetic mothers: Identification of the most characteristic and most frequent congenital anomalies. Am J Med Genet 51:108–113.

Martínez-Frías ML (1995): Primary midline developmental field. I. Clinical and epidemiological characteristics. Am J Med Genet 56:374–381.

Martínez-Frías ML (1996): Epidemiological analysis of the association of congenital diaphragmatic hernia with upper-limb deficiencies: A primary polytopic developmental field defect. Am J Med Genet 62:68–70.

Martínez-Frías ML, Cucalón F, Urioste M (1992): New case of limb body-wall complex associated with sirenomelia sequence. Am J Med Genet 44:583–585.

Martínez-Frías ML, Salvador J, Prieto L, Zaplana J (1984): Epidemiological study of gastroschisis and omphalocele in Spain. Teratology 29:377–382.

Martínez-Frías ML, Urioste M (1994): Segmentation anomalies of the vertebras and ribs: A developmental field defect: Epidemiologic evidence. Am J Med Genet 49:36–44.

Mastroiacovo P, Källén B, Knudsen LB, Lancaster PAL, Castilla EE, Mutchinick O, Robert E (1992): Absence of limbs and gross body wall defects: An epidemiological study of related rare malformation conditions. Teratology 46:455–464.

Miller ME (1983): Structural defects as a consequence of early intrauterine constraint: Limb deficiency, polydactyly, and body wall defect. Semin Perinatol 7:274–277. (Cited by Litwin et al., 1988.)

Miller ME, Graham JM, Higginbottom MC, Smith DW (1981): Compression-related defects from early amnion rupture: Evidence for mechanical teratogenesis. J Pediatr 98:292–297.

Moerman P, Fryns JP, Vandenberghe K, Lauweryns JM (1992): Constrictive amniotic bands, amniotic adhesions, and limb-body wall complex: Discrete disruption sequences with pathogenetic overlap. Am J Med Genet 42:470–479.

Pagon RA, Stephens TD, McGillivray BC, Siebert JR, Wright VJ, Hsu LL, Poland BJ, Emanuel I, Hall JG (1979): Body wall defects with reduction limb anomalies: A report of fifteen cases. Birth Defects XV (5A): 171–185.

Russo R, D'Armiento M, Angrisani P, Vecchione R (1993): Limb body wall complex: A critical review and nosological proposal. Am J Med Genet 47:893–900.

Russo R, Vecchione R (1996): Limb body wall complex: Craniofacial defects as a distinctive factor. Birth Defects XXX (1):157–164.

Seeds JW, Cefalo RC, Herbert WNP (1982): Amniotic band syndrome. Am J Obstet Gynecol 144:243–248.

Streeter GL (1930): Focal deficiencies in fetal tissues and their relation to intrauterine amputations. Contrib Embryol Carnegie Inst 22:1–44. (Cited by Russo et al., 1993.)

Tang TT, Oechler HW, Hinke DH, Segura AD, Franciosi RA (1991): Limb body-wall complex in association with sirenomelia sequence. Am J Med Genet 41:21–25.

Torpin R (1965): Amniochorionic mesoblast fibrous strings and amniotic bands. Am J Obstet Gynecol 91:65–75.

Van Allen MI, Curry C, Gallagher L (1987a): Limb body wall complex: I. Pathogenesis. Am J Med Genet 28:529–548.

Van Allen MI, Curry C, Walden CE, Gallagher L, Patten RM (1987b): Limb body wall complex: II. Limb and spine defects. Am J Med Genet 28: 549–565.

Viscarello RR, Ferguson DD, Nores J, Hobbins JC (1992): Limb-body wall complex associated with cocaine abuse: Further evidence of cocaine's teratogenicity. Obstet Gynecol 80:523–526.